Earth Observing System
AM-1 Spacecraft
Simulation Plan

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Prepared for:
National Aeronautics and Space Administration
Goddard Space Flight Center

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1. Introduction

1.1 Purpose

The purpose of this document is to define a comprehensive simulation plan for the EOS missions. Simulations will be designed to train operations personnel and support elements on EOS nominal and contingency operations for all mission phases. The simulations will exercise data interfaces, inter-facility communications, readiness of the ground system, and operational procedures.

Included is the simulation philosophy, along with guidelines and scenarios. For detailed operations, or interfaces see the reference section listed in Section 2.0.

1.2 Scope

This document defines simulations guidelines and procedures for participating elements, but does not detail those internal operations unique to each facility.

This document describes the following areas:

a) Simulation Management; defines simulation management and the operation teams roles and responsibilities.
b) Simulation support; defines all the supporting elements, their interfaces, data flow, and facility responsibility.
c) Simulation types; defines the different types of simulations, responsibilities and personnel required to support the simulation.
d) Simulation process; defines the simulation methodology, control and operations.

2. Applicable Documents

2.1 EOS Documents

The following documents are applicable to the EOS Simulation Plan to the extent specified herein.

1. EOS Observing System Mission Operations Plan, SES, Inc. (September 1996)
2. EOS Ground System Integration Plan (Preliminary), SES, Inc. (September 30, 1996)
3. Earth Observing System Mission Operations Concept Document, Omitron, Inc. (August 1996)
4. EOC Facility Utilization Plan, Omitron, Inc. (September 1996)
5. EOS AM-1 Mission Operations Concept, NASA/GSFC (May 1994)
6. SSIM Software Requirements Specification, LMMS (To be published)

3. Simulation Management

3.1 Introduction

Simulations will be designed to exercise system capabilities, institutional resources, operational procedures, and personnel. Simulations will be conducted on a non-interference basis, using standard scheduling procedures, elements and simulation resources to the maximum extent possible, consistent with the needs and objectives of each particular simulation. The SSim simulations will be operations oriented, with emphasis on personnel training, organizational interface validation and operational procedure validation. The simulation management is under the direction of the Flight Operations Director. The structure is depicted in Figure 1.

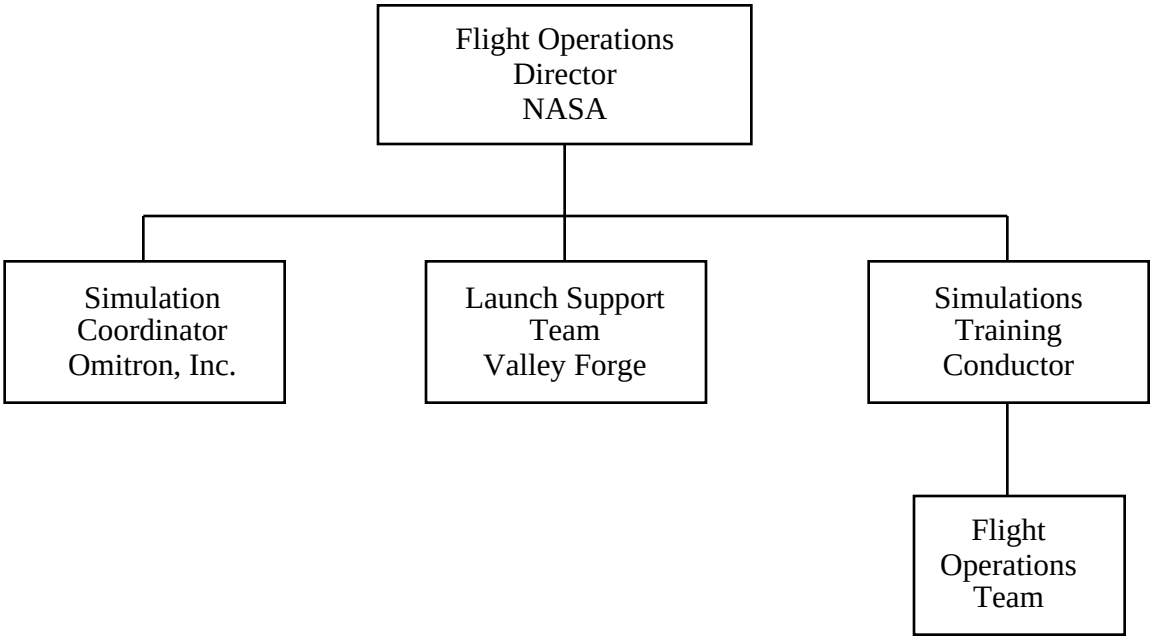

Figure 1 Simulation Management Structure

3.2 Flight Operations Director (FOD)

The Flight Operations Director (FOD) is responsible for pre-launch, launch and mission operations planning activities at the EOS Operations Center (EOC), including training simulations, nominal mission operations and spacecraft contingency proceedings.

3.3 Simulation Coordinator (SC)

The Simulation Coordinator (SC) is responsible for coordinating each SSim integrated simulation scenario. The SC will ensure that all simulation supporting elements are configured properly for each SSIM Integrated Simulation (IS). The SC responsibilities include the following:

a) Coordinate with necessary personnel to assure that simulation scripts are accurately inserted into the SSIM.

b) Conduct a simulation kick-off briefing, conduct post simulation debriefing and issue a post simulation report for all SSIM integrated simulations.
c) Coordinate resources required to conduct all SSIM integrated simulations.
d) Prepare documentation, as necessary, to meet simulation needs.

3.4 Launch Support Team (LST) / Valley Forge

The Launch Support Team (LST) will consist of launch specialists and EOS operations engineers from the manufacturer and EOS subsystem specialists to support launch operations and early orbit spacecraft checkout, respectively.

The Launch Support Team, or an appropriate subset, will support all launch management simulations where Go/No-Go decisions will be made, and activation and check-out simulations. Specific LST members may also be needed to support fully integrated simulations.

3.5 Simulations Training Conductor (STC)

The Simulations Conductor (STC) is responsible for conducting each SSIM Spacecraft Operation Exercise (SOE) and Ground Operations Exercise (GOE). The STC will ensure that all simulation supporting elements are configured properly for each training exercise. The STC's responsibilities include the following:

a) Develop simulation scenarios, timelines and scripts for SSIM simulation activities.
b) Lead the SSIM simulation team during all aspects of each simulation.
c) Coordinate the conduct of the training exercises.
d) Coordinate resources required to conduct SSIM training exercises; including the SSIM operators.
f) Prepare documentation, as necessary, to meet SSIM exercise needs.

3.6 Flight Operations Team (FOT)

The Flight Operations Team (FOT) is experienced in spacecraft operations and will be controlling the EOS mission satellites. Therefore, the training exercises (SOEs, GOEs) and Integrated Simulations (ISs) will emphasize on operation support systems, operations and contingency procedures, and the critical early mission timeline.

The FOT will participate in all integrated simulations and training exercises. FOT members may be used to support the development of the simulation scenarios and help run the simulation in an inter-active manner. The FOT personnel that help develop the simulation scenario will not be on console at the time of the scenario timeline.

4. Simulation Support

4.1 EOS Operations Center

Most simulation-related equipment is located within the EOS mission control center called the EOS Operations Center (EOC), illustrated in Figure 2. The EOC is located in Building 32 at GSFC, and is operated by the FOT. It contains systems and equipment to perform mission planning, scheduling, spacecraft and science instrument command and control, telemetry processing, analysis, testing, training and simulations for all EOS spacecraft, including simultaneous on-orbit support for multiple spacecraft, ground system and on-orbit tests, and training simulations.

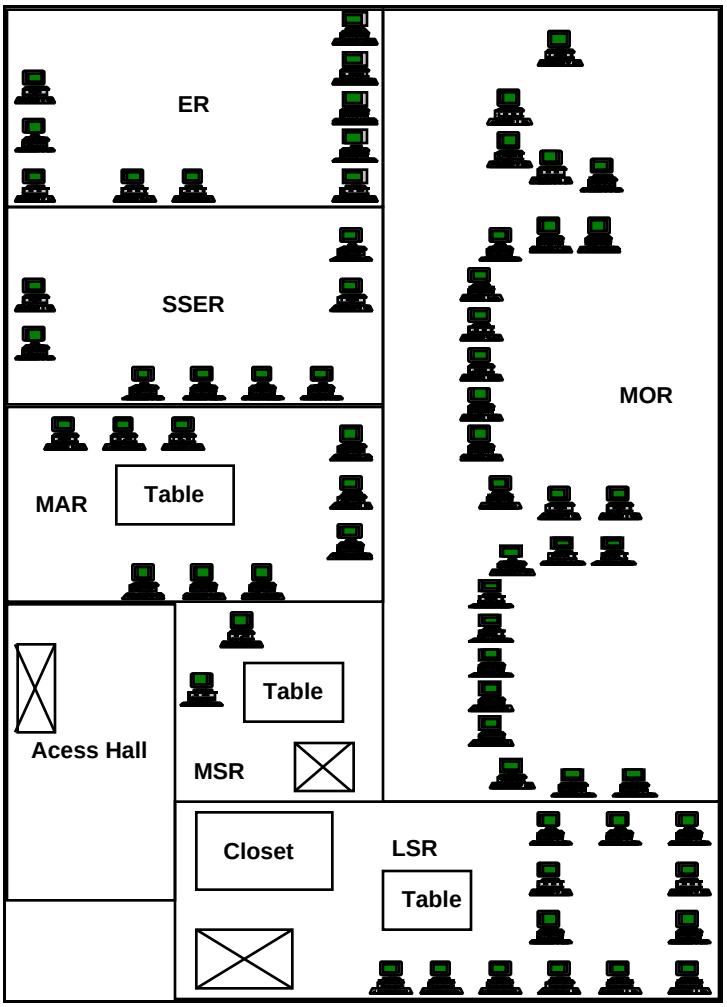

Figure 2 EOS Operations Center (EOC)

Each simulation scenario will have its own unique support requirement, thus all elements will not be required to support all simulations. Each element's support requirements will be coordinated in advance by the STC of all SSIM training exercises and the SC for all integrated SSIM simulations. The personnel and equipment required to support the simulations are defined in the sections detailing the simulations.

4.2 Simulations

Figure 3 illustrates a typical configuration of SSIM, the ETS High Rate System (HRS), and ground systems during simulations including simulated receipt of science data. As shown in the figure, integrated simulations typically will use high-rate science data to EOS Data and Operations System (EDOS) as well as SSim engineering data for spacecraft simulation. Integrated simulations may include simulation Space Network (SN) or ground system anomalies to train for anticipated problem areas requiring Network Control Center (NCC) and EDOS participation in contingency resolution.

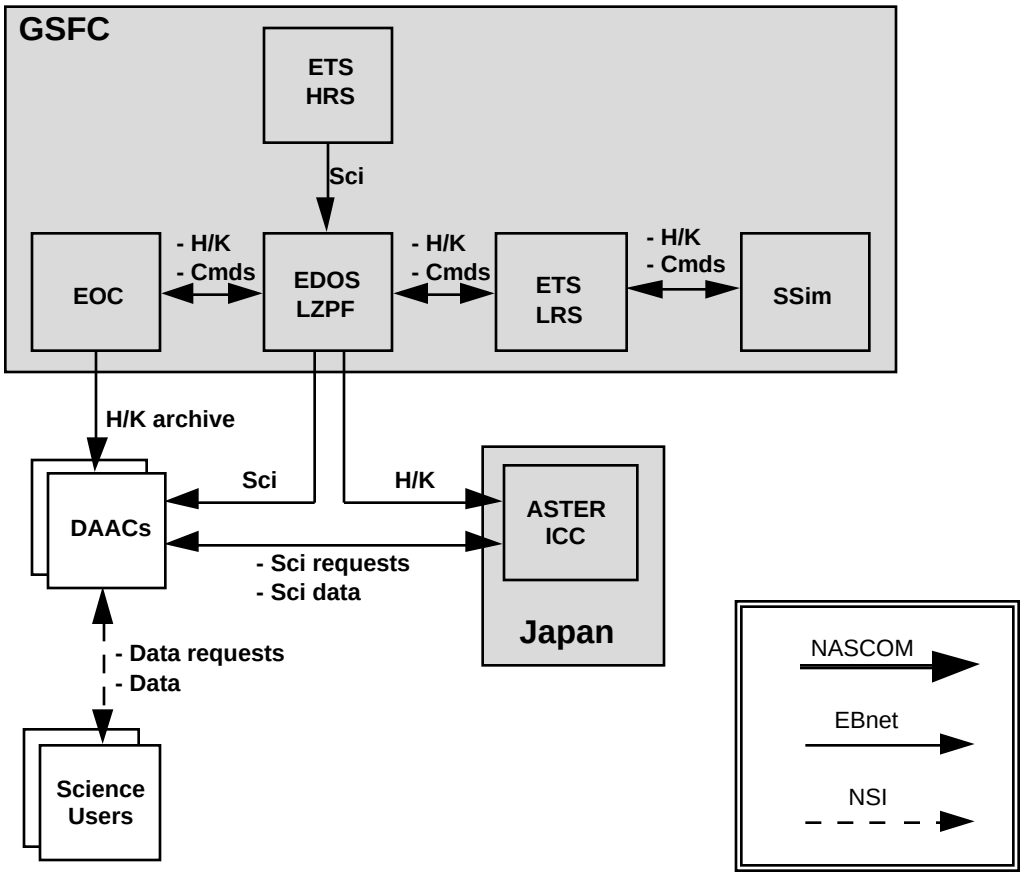

Figure 3 Configuration of Integrated Simulations

4.3 Science Operations

A few simulations may include Instrument Operations Teams (IOTs) at remote Instrument Operations Centers (IOCs) performing science instrument health and safety evaluations of instrument-related data, evaluating science-related data, or requesting pre-defined groups of instrument-related commands called Activities be scheduled for uplink to be performed by the spacecraft. Communication between IOCs and the EOC is via the NASA Science Internet (NSI).

All IOC facilities include a common set of software called an Instrument Support Toolkit (IST) provided by the EOSDIS Core System (ECS) contractor. The IST software may also be included in an integrated simulation.

5. Simulation Training

5.1 Definition

Simulations are used to provide an interactive training environment for operations, coordination, and the exercising of nominal and contingency procedures in as realistic an environment as possible. These simulations will exercise operator spacecraft knowledge, as well as mission preparedness. Anomaly identification (and resolution process), spacecraft launch and early orbit operation (nominal and contingency), on-orbit check-out and evaluation, network and inter-center communication, as well as launch management coordination will be exercised.

Three environments of EOS simulations will be exercised. These will include launch Real-Time nominal, science operations and contingency interactions procedures.

6. Simulation Process

6.1 General

The SC will coordinate with the STC to determine the major emphasis of training for a particular simulation. Upon defining the emphasis, the STC will develop a set of objectives for a given simulation. The SC will be responsible for performing a kick-off briefing, conducting the integrated simulation, coordinating the debrief, and issuing a post simulation report.

6.2 Simulation Scripting

Based on the objectives defined for a particular simulation, the STC will develop a script to exercise the appropriate elements to achieve the desired objectives. The script is developed by the Simulation Team (ST) —unknown to the operations team—using the nominal mission timeline. Off-nominal conditions will be inserted into the training exercises. The anomalies may have pre-defined contingency procedures or may require a contingency plan to be developed in Real-Time. The anomalies will be developed by the STC and inserted into the timeline at the direction of the STC. The FOD will approve all simulation timelines, training exercises and scenarios prior to the simulation.

6.3 Simulation Kick-Off Briefing

The integrated simulation kick-off briefing will be presented to the operations team by the SC. At a minimum, the briefing will consist of the following information: simulation start and stop times, on console time, mission timeframe to be exercised, known simulator deficiencies, special simulation unique configurations, critical documentation revisions (e.g., current revision of procedures), and action item status (from previous simulations).

The SC may not always provide the information or briefing for a particular topic, but is responsible for coordinating to ensure the topic is addressed. The first simulation kick-off briefing will provide more in-depth information regarding start up items (e.g., may provide a listing of voice communications available, a brief explanation of how anomalies are induced, etc.).

6.4 Simulation Set-Up

Each integrated simulation scenario will have its own unique control and operations requirements. It is the responsibility of the STC and SC to define the requirements, insure the proper control channels, and staffing for simulation operation. The voice loops will be defined for each simulation, on an as needed basis, and implemented in coordination with the STC. The simulation voice loops will differ from the normal operations voice loops in that there will also be special simulation control loops from the Simulation Coordinator to the supporting elements.

Voice and data flow channels will be tested prior to each simulation, under the supervision of the STC. The SC will start the simulation once all supporting elements are ready, as determined by the STC. The SC will announce the start of the simulation over the appropriate voice loops.

6.5 Simulation Execution

The SC will control the flow of the simulation timeline for each simulation. Data flow coordination will be performed via voice loop between the SC and the SSim Operator. Initial simulation start will be coordinated via voice loop between all participating areas. Telemetry flow will be in accordance with the timeline defined in the simulation kick-off briefing. The SC will control all data flow throughout the simulation. The simulation will be concluded when the defined timeline has been exercised or the FOD, STC, and the SC agree all objectives have been met. An announcement will be made on the loops that the simulation is concluded and will identify the starting time for the debriefing.

6.6 Summary Debrief

At the completion of each integrated simulation, the FOD and the SC will conduct a simulation debrief. The debrief is designed to review the conduct and quality of the previous exercise, address operational issues and assign action items (where required) to improve operational procedures and/or processes.

6.7 Post Simulation Report

The SC will be responsible for issuing a written simulation debrief report. The report will include a quick synopsis of the period simulated, major issues identified in the debrief, and a list of the action items assigned.

7. Simulation Scenarios

7.1 Scenario Definition

Scenarios will follow planned mission activities, and will primarily focus on the mission critical part of the timeline. There will be simulations that exercise the nominal procedures for these activities, and there will be training exercises (SOEs, GOEs) where malfunctions are inserted in the activity that are designed to exercise contingency procedures. When malfunctions are introduced, they will be inserted unexpectedly for the FOT, into the timeline. The FOT will treat them as actual mission anomalies and act accordingly.

7.2 Nominal Operations

These exercises will consist of simulation training activities for non-launch, routine spacecraft activities. Nominal operations exercises would include, but are not limited to, on-board recorder management, load/dump practices and time correlation.

7.3 Special Operations

Simulations of deployments, post-launch maneuvers and flight software patches are considered special operations. These exercises will familiarize the FOT with deployment sequences, on-board computer execution of pre-planned on-board commands, as well as deployment commands via Real-Time commands from the EOC. Simulations of orbit acquisition familiarize the FOT with applicable procedures, monitoring telemetry and verifying prerequisites which must be met prior to initiating orbit acquisition maneuvers.

7.4 Contingency Operations

One of the prime purposes of simulations is to exercise the off nominal or contingency operations procedures. Operations management provides a generic plan to respond in Real-Time to significant anomalies detected during early on-orbit activities to be used during simulations as during on-orbit supports.

Appendix A
AM-1 Mission Specifics

Simulations Schedule

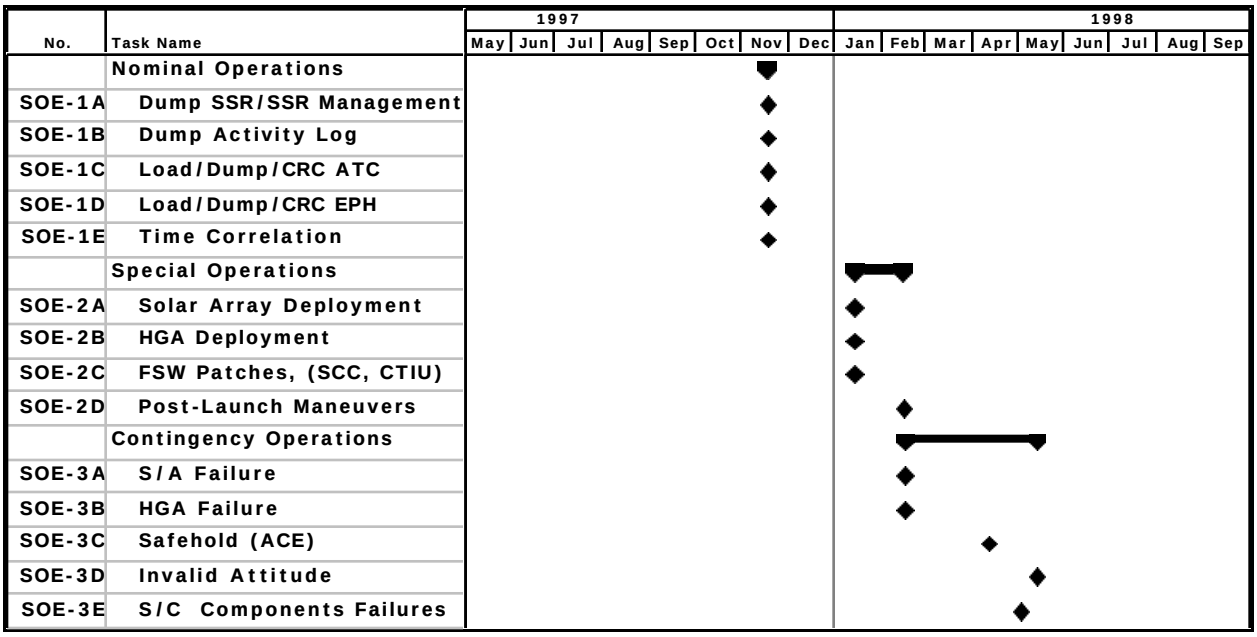

Figure 4 Spacecraft Operations Exercises (SOE)

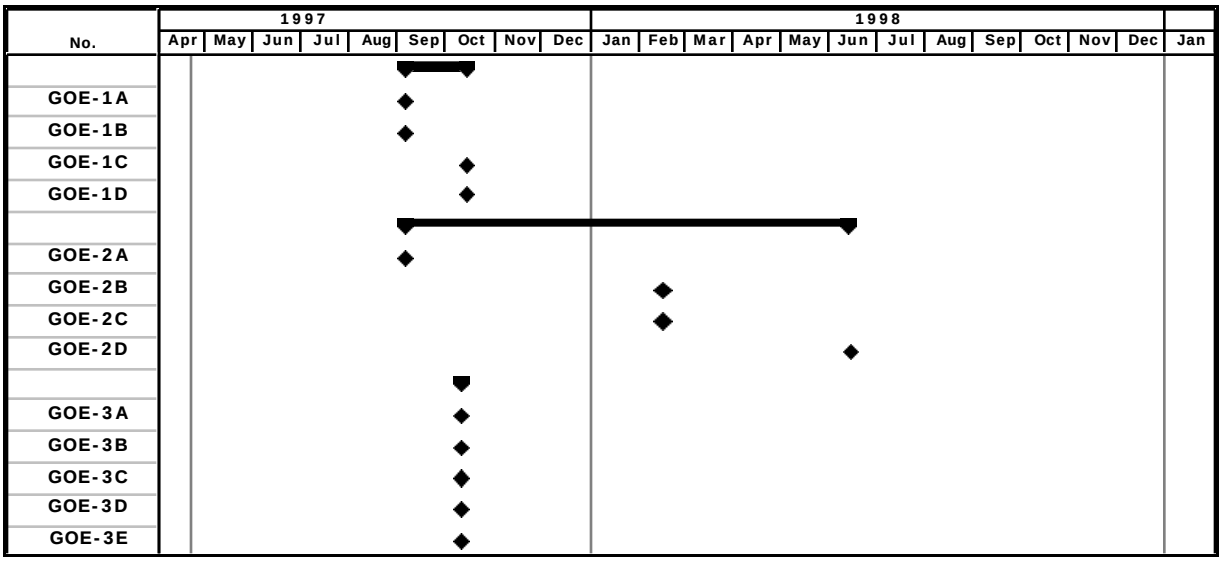

Figure 5 Ground Operations Exercises (GOE)

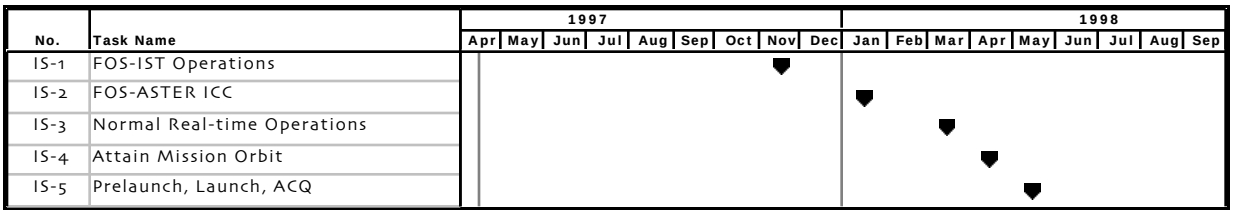

Figure 6 Integrated Simulations (IS)

SSIM Training Exercises

Table 1 Spacecraft Operations Exercises

	Activity Simulated	Date	Participants	Simulation Requirements
	Normal Operations			
SOE-1A	Dump SSR/SSR Management	11/97	1, 6	ETS, SSIM
SOE-1B	Dump Activity Log	11/97	1, 6	ETS, SSIM
SOE-1C	Load/Dump/CRC ATC	11/97	1, 6	ETS, SSIM
SOE-1D	Load/Dump/CRC EPH	11/97	1, 6	ETS, SSIM
SOE-1E	Time Correlation	11/97	1, 6	ETS, SSIM
	Special Operations			
SOE-2A	Solar Array Deployment	1/98	1, 6	SSIM
SOE-2B	High Gain Antenna Deployment	1/98	1, 6	SSIM
SOE-2C	FSW Patches (SCC, CTIU)	1/98	1, 6, 13	SSIM
SOE-2D	Post Launch Maneuvers	2/98	1, 6, 10	SSIM
	Contingency Operations			
SOE-3A	Solar Array Deployment	2/98	1, 6	SSIM
SOE-3B	High Gain Antenna	2/98	1, 6	SSIM
SOE-3C	Safehold Recovery (ACE)	4/98	1, 6	SSIM
SOE-3D	Invalid Navigation/Attitude	5/98	1,6,10	SSIM
SOE-3E	S/C Component Failures	5/98	1,6	SSIM

Participants column is: 1 = FOT (for *all* sims), 2=EBnet, 3=RF SOC, 4=IOTs, 5=TGT, 6=EDOS, 7=WOTS, 8=ASTER ICC & JPL Gateway, 9=NCC, 10=FDD, 11=DAAC(s), 12 = GSIF, 13 = SDVF

Table 2 Ground Operations Exercises

	Activity Simulated	Date	Participants	Simulation Requirements
	Nominal Operations			
GOE-1A	Planning	9/97	1, 4, 8, 10	
GOE-1B	Scheduling	9/97	1, 4, 6, 8, 9	
GOE-1C	Command Management	10/97	1	
GOE-1D	Normal R/T OPS Loads	10/97	1, 6	ETS, SSIM
	Special Operations			
GOE-2A	PDB Implementation	9/97	1, 4, 6, 8	ETS, SSIM
GOE-2B	Schedule Ground Station	2/98	1, 7, 10	
GOE-2C	Maneuvers	2/98	1, 6, 9, 10	SSIM
GOE-2D	Launch Rehearsal	6/98	All	SSIM
	Contingency Operations			

GOE-3A	AOS Blind, Late, Negative	10/97	1, 6	ETS, SSIM
GOE-3B	Ground Station Support	10/97	1, 6	ETS, SSIM
GOE-3C	RT Server Failover	10/97	1	ETS, SSIM
GOE-3D	LAN Failover	10/97	1	
GOE-3E	DS Failover	10/97	1	

Participants column is: 1 = FOT (for *all* sims), 2=EBnet, 3=RF SOC, 4=IOTs, 5=TGT, 6=EDOS, 7=WOTS, 8=ASTER ICC & JPL Gateway, 9=NCC, 10=FDD, 11=DAAC(s), 12 = GSIF, 13 = SDVF

SSIM Integrated Simulations

Table 3 Integrated Simulations

	Activity Simulated	Date	Participants	Simulation Requirements
IS-1	FOS-IST Interactions, Normal Operations	11/97	1, 2, 4, 6	ETS
IS-2	FOS-ASTER ICC Interaction, Normal Operations	1/98	1, 2, 6, 8	ETS
IS-3	Normal Real-Time Operations	3/98	1, 2, 4, 6, 8	SSIM
IS-4	Attain Mission Orbit	4/98	1, 6, 10	SSIM
IS-5	Pre-launch, Launch, Acquisition	5/98	All	SSIM

Participants column is: 1 = FOT (for *all* sims), 2=EBnet, 3=RF SOC, 4=IOTs, 5=TGT, 6=EDOS, 7=WOTS, 8=ASTER ICC & JPL Gateway, 9=NCC, 10=FDD, 11=DAAC(s), 12 = GSIF, 13 = SDVF

Training Exercises

This level of FOT training will be conducted using the spacecraft and ground operations exercises, the building blocks for the integrated simulations. The individual activities will be describes as follows:

SOE Normal Operations

Normal operations will include SSR management, dump of the activity log, the loading and dumping of the CRC ATC and ephemeris, as well as exercising time correlation.

SOE-1A Dump SSR/SSR Management

The SSR Management exercise will provide the capability to ensure that all aspects of SSR Management have been simulated.

1. SSR Buffer Predictions - This includes the Planning and Scheduling Subsystem to predict and display on the timeline SSR Buffer status based upon science data collection activities and contact schedules.
2. SSR Management During a Nominal Contact - This includes the ability to request and receive SSR buffer predicts from PAS, create and send an SSR dump command to the FUI command request window, register and receive Housekeeping, UPD and CODA mnemonics, monitor and display SSR Buffer status in Real-Time and finally to send SSR buffer actuals to SSR Updater following the spacecraft contact.
3. SSR Management During a Contact with RF Failures - FOT will ensure that the SSR Management tools responsible for detecting and recommending recovery procedures works correctly. This includes the ability to detect RF failures reported in NCC UPDs and to recommend recovery procedures.
4. SSR Management During a Contact with Playback Data Loss - The FOT will exercise the SSR Management tools ability to detect playback data loss as reported in CODAs and to recommend recovery procedures. The FOT will also verify PAS ability to receive SSR Buffer Actuals from SSR Management and correct the SSR Buffer status to ensure any missed data is recovered during the next spacecraft contact.

SOE-1B Dump Activity Log
This exercise will demonstrate the ability to receive activity log messages embedded in housekeeping telemetry. During Real-Time create and display "Event Message" of interpreted activity log entry and indicate severity. Duplicate activity log entries should not have event message generated. Only one entry trickles down in telemetry at a time. The FOT will dump the activity log table and verify that the data is processed by the Activity Log Monitor. This simulation will also demonstrate the ability of the FOT to look up information in the Activity Log Database. This includes the most current 300 entries as well as all entries from the beginning of the Mission.

SOE-1C Load/Dump/ATC
The FOT will use the Planning And Scheduling (PAS) and Command Management System (CMS) software tools for the generation of the Absolute Time Command (ATC) loads for the AM-1 spacecraft. When uplinked, the loads are verified by examining a Cyclic Redundancy Check (CRC) status, which is included in the housekeeping telemetry. The ATC will prepare the spacecraft for the upcoming support by slewing the HGA to the appropriate azimuth and elevation angles. The ATC will contain the HGA pre-contact commands (TDRSS ID, Slew and Track) for each support.

SOE-1D Load/Dump/Ephemeris
The FOT will generate a TDRS position (TDRS ephemeris) table load and uplink it to the spacecraft on a daily basis. The TDRS On-board Navigation System (TONS) flight software will automatically generate the EOS AM-1 position (spacecraft ephemeris). The TDRS and spacecraft ephemerides will be used by the Attitude Determination and Control (ADAC) flight software to point the HGA to the selected TDRS (azimuth and elevation step commands).

SOE-1E Time Correlation
The FOT will exercise managing the spacecraft clock and keeping track of how much the spacecraft clock has drifted. Once the oscillator drift rate has been analyzed the FOT will create an activity which will be scheduled routinely to keep the clock within +/-50 ms. During Real-Time the FOS will provide a coarse estimate of the clock every minute. If this estimate is not within +/-100ms the FOS will recommend updating the oscillator frequency with the appropriate parameter.

SOE Special Operations

SOE special operations will include: solar array and HGA deployment, flight software patches, post-launch maneuvers and time correlation.

SOE-2A Solar Array Deployment
This exercise will simulate a nominal Solar Array deployment. It will begin with the Solar Array in the stowed position and end with the Solar Array blanket fully deployed and tracking the sun. There are four distinct events involved in this exercise: releasing the Blanket Box, separating the Blanket Box halves, extending the Solar Array Mast, and initiating Solar Array Rotation. The nominal execution of Solar Array deployment will take place through the spacecraft's stored commands.

SOE-2B HGA Deployment - Nominal Case
Nominal Deployment of the 4.5' diameter Ku/S-band TDRSS parabolic reflector antenna will be simulated. The Pyrotechnic Bus will be enabled, the Pyrotechnic Relay

Assembly (PRA) will be armed, Non-explosive Actuators (NEAs) will be fired, and HGA boom deployment will be monitored. Once the ball-release devices are released, the graphite/epoxy boom will rotate 180 degrees about a spring driven hinge to its fully deployed state.

SOE-2C FSW Patches (SCC, CTIU)
This simulation will demonstrate the ability to: create a patch, test patch with Flight Software Test Bed (FSTB) and SSIM, load patch, dump patch, verify execution of patch on-board. The SDVF will create a Flight Software (FSW) maintenance load (patch). They will test it on the FSTB using CSTOL procedure. The CSTOL procedure will be translated to an ECL procedure. The patch will be tested on SSIM by the FOT to determine whether the patch that was uplinked performs as expected. For every patch, a "back-out" patch shall be developed and tested on both FSTB and SSIM. FSW maintenance personnel will oversee loading of all patches to the spacecraft in the EOC.

SOE-2D Post Launch Maneuvers
This simulation should be performed to familiarized the FOT with the orbit acquisition maneuvers required post launch, to achieve the mission orbit. The simulation should contain the most realistic steps taken to do the maneuvers including interfaces with FDD.

SOE Contingency Operations

SOE contingency operations will include: solar array and HGA failures, safehold recovery and invalid navigation practices.

SOE-3A Solar Array Failure
This exercise will simulate a contingency Solar Array Deployment. It will begin with the Solar Array in the stored position, and end with the Solar Array Blanket fully deployed and tracking the Sun. This exercise will simulate failure conditions that would cause the deployment not to occur in a nominal manner. This could include a number of hardware failures, as well as having to execute the deployment through Ground Commanding.

SOE-3B HGA Deployment - Single Failure Case
Deployment of the 4.5' diameter Ku/S-band TDRSS parabolic reflector antenna, suffering a single point failure, will be simulated. A failure of one of the five ball-release mechanisms to release and all procedures required to recover will be simulated. Once all of the release devices are released, the graphite/epoxy boom will rotate 180 degrees about a spring driven hinge to its fully deployed state. Two additional situations that will be consider are SCC halt recovery and CTIU failure recovery.

SOE-3C Safehold Recovery (ACE)
This simulation should include a general recovery from sun pointing, earth pointing and inertial pointing safehold modes (SHM). Dealing with specific failures which would cause SHM transition, are not necessary due to the many possible combinations of entries. A simulation of an SCC halted SHM should also be performed.

SOE-3D Invalid Navigation
Real-Time checks of Navigation Filter performance, when in normal operating mode, should be simulated. Upon detection of filter divergence, regardless of cause, simulate the procedure to upload new states and reinitialize the filter. During Real-Time contacts, verify that Doppler data is being processed or use the Navigation telemetry indicators and counters to determine the error and appropriate course of action.

SOE-3E Spacecraft Component Failure
The FOT will simulate a variety of spacecraft subsystem component failures. The list of failures to simulate will be determined by committee. It will include but not limited to the following failures: RWA, ESA, CTIU, Thruster (stuck open, stuck closed), Transponder, Battery Cell, Heater (stuck on, stuck off).

GOE Normal Operations

GOE normal operations exercises will include the planning and scheduling of operations, as well as exercising the Command Management System (CMS) and uplinking real-time operations loads. The FOT will use the Planning and Scheduling (PAS) and CMS software tools for the generation of the ATC loads for the AM-1 spacecraft.

GOE-1A Planning
This exercise will be utilizing FDD planning aids, interference and visibility predictions and acquisition data.

GOE-1B Scheduling
The FOT will initiate the Planning and Scheduling (PAS) event schedule tool. This tool executes a batch process and the data management system will receive all of the FDF products and initiate PAS processes to validate the FDF products. This exercise will account for : TDDRS, STS from ASTER, schedule activities and BAPs, activity level constraints, late schedule changes and TDRS maneuvers.

GOE-1C Command Management System
The FOT will be generating the Detailed Activity Schedule (DAS), ground script and Absolute Time Commands (ATC) loads. This exercise will practice verifying that the DAS and ground script contain the SSR commands, start of playback, duration of playback and predicted SSR counters at the beginning of contact.

GOE-1D Real-time Operations
This exercise will include the activities discussed in SOE Normal Operations, with the additions of command requests that are used for non-planned events (commands, procedures, etc.), as well as ICC and IST connectivity.

GOE Special Operations

GOE special operations will include PDB implementation, scheduling ground stations, maneuvers and launch rehearsal exercises.

GOE-2A PDB Implementation
This simulation will include Project Database (PDB) processing, CCB approving , Report Generation and Distribution. The simulation will begin by ingesting data from the Valley Forge Database and edits from the FOT and IOTs. The DBA will generate a new release of the PDB and a validation report will be generated. Three reports or listing will be created which shows all data that passed validation: Command Report, Telemetry Report and an Activity Report. The Validated PDB will be sent to the ICC, ETS and the GSFC Library. The Operational PDB will be sent to the ISTs.

GOE-2B Scheduling a Ground Station
In preparation for on-orbit operations, the FOT will conduct simulations to rehearse certain situations which will be encountered during the mission. The scheduling of a Ground Station is a capability available to the FOT for support in the event of TDRSS

unavailability. An exercise with the Wallops Orbital Tracking Station (WOTS), the Flight Dynamics Facility (FDF), and the EOS Operations Center (EOC) would test each facility's functionality, response time and provide a baseline for standard operating procedures. Such a rehearsal would also identify any deficiencies among the interfaces and allow sufficient time for corrections prior to on-orbit operations.

GOE-2C Maneuvers
The FOT should simulate the various ADAC related maneuvers for the s/c. These maneuvers should consist of an attitude bias maneuver, an attitude slew maneuver (with biases), an attitude bias maneuver for an orbit adjust purpose, and the large deep space/moon calibration pitch maneuver.

GOE-2D Launch Rehearsal
Reference IS-5 Pre-launch, Launch and Acquisition.

GOE Contingency Operations

GOE contingency operations will include: AOS anomalies, ground station support problems, and failovers with the RT server, LAN and DS.

GOE-3A AOS Blind, Late, Negative
The purpose of this exercise will be to enhance the skills of the On-Line Flight Team for real time operations. The exercise will consist of scenarios for Blind, Negative, and Late Acquisition of Signal(TDRS).

GOE-3B Ground Station Support
The Ground station support GOE will be performed to that ensure members of the on-line controller staff are capable of conducting spacecraft contacts with the contingency ground stations for AM-1. The FOT will practice the activities and exercise the procedures that are expected to occur in the event of an anomaly that prohibits real-time spacecraft contacts via the TDRSS. These activities will include X-band and S-band SSR dumps, spacecraft activity log dumps and routine spacecraft command loads.

GOE-3C RT Server Failover
The FOT will simulate FOS Real-Time Server (RTS) Failover. The RTS is the only machine which can create and send commands. The failure recovery is an automated (FOT uses ground directive to initiate), not automatic function. Users with mirrored or tailored connections will be automatically connected to the new ACTIVE string.

GOE-3D LAN Failover
The FOT will simulate Local Area Network (LAN) Failover. The EOC Network consist of two LANs: Operational and Support. The Operational LAN will be used for Real-Time operations. The Support LAN will be used by the FOS Sustaining Engineers to code and test FOS enhancements. The FOT will simulate Failover of Real-Time operation activities from the Operational LAN to the Support LAN. Devices will be attached to both the Operational and Support LANs allowing devices to switch function without reconfiguring hardware (switch-over accomplished in software).

GOE-3E DS Failover
The FOT will simulate Data Server (DS) Failover. The DS stores the Project Database Tables as well as data for a minimum of 7 days. This includes: Solid State Recorder back orbit data, event messages, FDD and NCC products, etc. The failure recovery is an automated (FOT uses ground directive to initiate), not automatic function.

FOT Integrated Simulations

The FOT will be involved with 4 to 5 full scale integrated simulations (ISs) that are built from the GOEs and SOEs training exercises. The ISs will practice the procedural implementation of all control center entities and exercise the coordination between these facilities.

IS-1 FOS-ASTER Interactions, Normal Operations
This simulation will focus on FOS-ASTER planning and scheduling, as well as exercising products for uplink command loads and tables for use by SSim.

IS-2 FOS-IST Interactions, Normal Operations
This simulation will focus on FOS-IST planning and scheduling, as well as exercising products for uplink command loads and tables for use by SSim.

IS-3 Normal Real-Time Operations
This integrated simulation will include SSR management, dump of the activity log, the load of the ATC and ephemeris, as well as exercising time correlation. For more details of these particulars, reference Spacecraft Operations Exercises SOE-1A through SOE-1E above.

IS-4 Attain Mission Orbit
The orbit adjust mission phase is to boost the spacecraft to its operational science taking orbit after the initial orbit insertion by the launch vehicle. The orbit adjust simulation will exercise orbit adjust procedures, trim maneuvers and Go/No-Go decisions for maneuvers

IS-5 Pre-launch/Launch/Acquisition
Pre-launch simulations are launch configuration preparation and Go-for-launch activities that focus on spacecraft and instrument configuration prior to lift-off. The main objective for the launch simulation is to stress system interfaces for problem solving between personnel at all levels from the launch mission management team to the operations, and stress the physical resources supporting the EOS mission.

The FOT will practice voice link confirmations, SCC/CTIU dumps, rate nulling and earth acquisition. Day/night transition and AOS/LOS will be simulated, FDF range data will be provded and the deployment of the solar array and HGA via ground command will be practiced. This simulation will include the following instrument activities:

- ASTER: ENA both op & survival/cooler power feed (no later than 45 minutes)
- CERES: ENA survival (not later than 5 hours)
- MOPITT: Choppers and l-mod cells powered off & survival mode set (1 min.)
- MODIS: Power feed DIS at PDU, enable survival power (12 hours to 20 hours)
- MISR: Power feed ENA at PDU, survival power ENA

Appendix B
SSim Lessons Learned

Appendix C
Phonetic Pronunciation and Nomenclature for Voice Network Communications

This appendix describes standard pronunciation and nomenclature used for voice communication over networks, including the phonetic alphabet, phonetic numerals, and standard nomenclature for providing or requesting information.

Phonetic Alphabet

To avoid ambiguity or misunderstanding while communicating verbally over networks, references to letters of the alphabet use an accepted phonetic alphabet including words to represent letters. The words in the phonetic alphabet are chosen to sound unlike other commonly used words to avoid potential misunderstanding.

The phonetic alphabet is:

A:	Alpha	F:	Foxtrot	K:	Kilo	P:	Papa	U:	Uniform
B:	Bravo	G:	Golf	L:	Lima	Q:	Quebec	V:	Victor
C:	Charlie	H:	Hotel	M:	Mike	R:	Romeo	W:	Whiskey
D:	Delta	I:	India	N:	November	S:	Sierra	X:	X-ray
E:	Echo	J:	Juliet	O:	Oscar	T:	Tango	Y:	Yankee
								Z:	Zulu

For example, the sequence of letters "DTBP" pronounced "dee tee bee pee" can be easily misunderstood, whereas ""Delta Tango Bravo Papa" is unambiguous.

Exceptions include using multiple letters in rapid succession when pronouncing commonly accepted program-unique or internationally recognized acronyms in unambiguous situations, such as AM (pronounced ay-em), PCM (pronounced pee-see-em), PM, GMT, RTS, VHF, UHF, RF, GSFC, JPL, ICC, NCC, EOC, etc.

Phonetic Numerals

As with letters of the alphabet, phonetic number pronunciations avoid ambiguity when communicating over networks. Phonetic number pronunciations are:

1:	Won	3:	Tha-ree	5:	Fi-yuv	7:	Seven	9:	Nin-er
2:	Too	4:	Fow-er	6:	Six	8:	Ate	0:	Zee-ro

Since common pronunciation of "fifty microvolts" can be easily misunderstood for "fifteen microvolts", multiple-digit numbers are often pronounced digit-by-digit. For example, "fifty" becomes "five-zero" pronounced "fi-yuv zee-ro", clearly differentiated from "fifteen", which becomes "one five" pronounced "won fi-yuv". "Fifty microvolts" hence becomes "fi-yuv zee-ro microvolts." Additional examples include 15 ("won fi-yuv"), 150 ("won fi-yuv zee-ro"), and 1500 ("won fi-yuv zee-ro zee-ro").

Exceptions include commonly accepted or unambiguous sounding groups of numbers whose meaning is clearly understood from the context in which they are used, such as "a four eighty six CPU", "Boeing seven forty seven", and "DOS six point two".

Common sense often dictates usage to avoid misunderstanding. For example, "The current is 6.2 amps and the voltage is 6.2, too" can be misunderstood to indicate a voltage of 6.22 regardless of

context or numeric pronunciation. Instead, use "... the voltage is 6.2 *also*", or "... the voltage is also 6.2", or preferably "... the voltage is 6.2 volts."

Voice Network Procedure Nomenclature and Meanings

To avoid misunderstanding and ambiguity, network verbal communication includes the standard nomenclature and meanings illustrated in Table 4.

Table 4 Network Voice Communication Nomenclature

Word or Phrase	Meaning
Affirmative	Yes
All after ___	Refers to all transmission following _. For example, "Goldstone, say again all after _."
Break-break	I wish to interrupt a conversation in progress. This is used only to interrupt with urgent information which must be communicated prior to an on-going conversation continuing.
Copy	I understand.
Disregard	Cancel my transmission in progress, or cancel my last transmission. For example, "Disregard my last two numbers, and replace with ___."
Figure	Numerals will follow. Need not be used when requesting or providing readouts, or when transmitting clock times. For example, "At zero one hundred hours send command figure one niner" (i.e. at 01:00:00 send command 19).
I spell	I shall spell the following phonetically. For example, "Dog. I spell. Delta Oscar Golf. Dog."
Negative	No or not.
On my mark	A significant time-critical event will occur shortly, and I shall provide a countdown at 1-sec intervals starting from 10, 5, or 2, with the work *mark* following one second after the number *one*. Frequently used to send a command or for synchronization of clocks. For example, "We shall send command XYZ on my mark . five .. four .. three .. two .. one .. mark."
Read back	Repeat my last remark, or a specified portion of it. For example, "Madrid, AM Control. Carrier-on time, zero four one two six five. Read back all after time." Madrid then replies, "AM Control, Madrid. I read back zero four one two six five."
Roger	I have received your transmission successfully. Do not use *Roger* to replace *affirmative* or *negative*. *Affirmative* means "yes", whereas *roger* means "I understand."
Say again	Repeat your last transmission, or a portion of it. For example, "Say again all after ___."
Speak slower	You are talking too fast, and I cannot understand; please slow down.
Stand by	I must pause for a few seconds. Since *stand by* requires the called party to ignore other calls to await your continued transmission, use this only if the waiting period is less than the time required to break and re-establish transmission.
Unknown station	I do not know the identity of the station calling me. For example, "Unknown station, AM Control. Say again", or "Station calling AM Control, say again."

Word or Phrase	Meaning
Wilco	I have received your message, I understand it, and I will comply. For example, "ASTER Control, AM Control. Wilco." Do not use *roger* in conjunction with *wilco*.
Word after	I refer to the word after ___. For example, "Goldstone, AM Control. Say again word after ___."
Word before	I refer to the word before ___. For example, "Goldstone, AM Control. Say again word before ___."
Words twice	Communication is difficult. Transmit (or I shall transmit) each word or word group twice.

Appendix D
Acronyms

ADAC	Attitude Determination And Control
AOS	Acquistion of Signal
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATC	Absolute Time Command
CMS	Command Management System
CRC	Cyclic Redundancy Check
DAAC	Distributed Active Archive Center
EBnet	EOSDIS Backbone Network
ECS	EOSDIS Core System
EDOS	EOS Data and Operations System
EOC	EOS Operations Center
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
ETS	EOSDIS Test System
FDD	Flight Dynamics Division
FOD	Flight Operations Director
FOS	Flight Operations Segment
FOT	Flight Operations Team
GOE	Ground Operations Exercise
GSFC	Goddard Space Flight Center
GSIF	Ground Station Interface Facility
HK	housekeeping
HRS	High Rate System
ICC	Instrument Control Center
IOC	Instrument Operations Center
IOT	Instrument Operations Team
IS	Integrated Simulation
IST	Instrument Support Toolkit
JPL	Jet Propulsion Laboratory
LST	Launch Support Team
NASA	National Aeronautics and Space Administration
NCC	Network Control Center
NSI	NASA Science Internet
OV	On-orbit Verification
PAS	Planning And Scheduling
RF SOC	Radio Frequency Simulations Operation Center
SC	Simulation Coordinator
SDVF	Software Development and Verification Facility
SN	Space Network
SOE	Spacecraft Operations Exercise
SSIM	spacecraft simulator
ST	Simulation Team
STC	Simulations Training Conductor
TGT	TDRSS Ground Terminal
TONS	TDRS On-board Navigation System
WOTS	Wallops Orbital Tracking Station